American representative, unanimously awarded the first prize to Mr. Guilbert for the method which enabled him to predict with precision the displacements and variations of centers of high and low pressure over Europe. Depressions and high areas invisible on the weather map when interpreted by methods heretofore used, were predicted by Mr. Guilbert. The author claims to be able to forecast radical changes in the barometric situation, both as to the form and the movement of the centers of high and low areas, for twenty-four hours in advance, with a precision far above that afforded by present methods. Heretofore the forecaster has to a very large extent assumed that a depression already discernible upon the weather map would follow a path already indicated by its previous movement, and that it would follow this path with but slight modifications in form or intensity. It was only in rare cases that a forecast of the *formation* of a low or high area was attempted. According to the statements of Mr. Guilbert he is able by his method to foretell the *inception* and the *dissolution* of storms.

Guilbert's new method is based upon what he terms the principle of the *normal wind*. The normal wind is defined as a wind whose force is directly proportional to the barometric gradient. Thus, on a scale of 0 to 9, a light wind (force 2) is normal for a gradient of 1 mm. per geographical degree of 111 km.; a moderate wind (force 4) is normal for a gradient of 2 mm., etc. This scale is given more in detail in the following paragraphs.

Guilbert's rules have been summarized by M. Brunhes, the chairman of the jury of award, who has contributed a valuable theoretical discussion of the rules (see Archives des Sciences Physiques et Naturelles for July, 1906).

According to M. Brunhes, the three rules announced by Guilbert may be summarized as follows:

1. Every depression that gives birth to a wind stronger than the normal will fill up more or less rapidly. On the other hand, every depression that forms without giving rise to winds of corresponding force will deepen, and often depressions that are apparently feeble will be transformed into true storms.
2. When a depression is surrounded by winds having varying degrees of excess or deficiency, as compared with the normal wind, it moves toward the region of least resistances. These favorable areas are made up of regions in which the winds are relatively light, and especially of such as have divergent winds with respect to the center of the depression.
3. The rise of pressure takes place along a direction normal to the wind that is relatively too high, and it proceeds from right to left; an excessive wind causes a rise of pressure on its left.

The results attained by Mr. Guilbert in the international competition were so far superior to those of any of his competitors that his methods are worthy of the closest study. A translation is here given of the paper presented by the author in which his new method is worked out in detail. How far the successful forecasting of Mr. Guilbert in this competition was due to the principle announced and how much is to be attributed to the cumulative experience of the forecaster remains to be demonstrated. The rules can be readily put to the test of experience, and the paper of Mr. Guilbert should receive the careful consideration of all who make weather forecasts.

PRINCIPLES OF FORECASTING THE WEATHER.

By GABRIEL GUILBERT, of Caen. Dated Liège, Belgium, September 28, 1905. [Translated by O. L. Fassig.]

The method which we employ in forecasting the weather at short range is based on the principle of the *normal wind*.

The normal wind is that whose force is directly proportional to the barometric gradient.

In the scale of winds from 0 to 9, a *light* wind (force 2) is *normal* for a gradient of 1 mm. per geographic degree of 111 km.

A *moderate* wind (force 4) is normal for a gradient of 2 mm.

A *fresh* wind (force 6) is normal for a gradient of 3 mm.

A *high* wind (force 8) is normal for a gradient of 4 mm.

In departing from these proportional coefficients, the winds are abnormal either by *excess* or by *deficiency*. Thus, 3 will be abnormal by *excess* for a gradient of 1 mm. per degree; in like manner 5, 7, and 9, for gradients of 2, 3, and 4 mm., respectively:

Inversely a calm (0) will be *abnormal by deficiency* for a gradient of 1 mm.; similarly 3, 5, and 7, for gradients of 2, 3, and 4 mm., respectively.

We have cited anomalies of but small importance, but it is not rare in observations to find 7 with a gradient of 2 mm., 9 with 3 mm., and, inversely, 3 or 4 with a gradient of 3 mm.

As a result of this scale and this principle, high winds and even gales can be *abnormal by deficiency*, that is to say, relatively too light for the gradient considered; and, inversely, light or moderate winds may be *abnormal by excess* in considering the gradient referred to.

Of course, these coefficients of wind force are at present dependent upon the estimation of observers, and science will some day require anemometric measures; but, in the meantime, the approximate estimate of this velocity of the air at the surface of the earth, *and at the surface only*, is sufficient for making a forecast *twenty-four hours in advance* of variations of pressure, whether rising or falling.

We maintain that no depression can subsist unless there be as complete equilibrium as possible between the force of the wind which it causes and the gradient which it forms.

To produce this equilibrium the force of the wind must be proportional to the gradient; there is then equality between the *centripetal* and *centrifugal* forces which are in constant struggle in every barometric depression. The gradient represents the centrifugal force, the wind the centripetal force. If at any point of a cyclone one of the forces predominates, there is a change in the form of the cyclonic whirl.

This change will take place in the direction of extension if the centrifugal force represented by the gradient is greater than the relatively feeble force of the wind. If, on the contrary, it is the centripetal force, represented by the velocity of the wind, which is the stronger, the whirl will undergo a *reduction* more or less noticeable.

Consequently, in application, with a wind *abnormal by excess*, there will be a *rise in pressure*, generally *proportional to the excess* of the wind observed.

Inversely, with a wind *abnormal by deficiency*, there will be a *fall in pressure* directly proportional to the importance of the observed anomaly.

With a *normal* wind the variations in pressure will be *nil* or slight.

It follows from this law and these observations that the wind is in reality *the enemy of the depression;* that it is centripetal, in *conflict* with the centrifugal force represented by the gradient; that it has the power to fill up cyclonic storms and cause them to disappear.

Hence, every depression which gives rise to winds above the normal in force will fill itself up more or less rapidly, in whole or in part.

Depressions arriving from the ocean, which give rise to too high winds, can not advance, but remain stationary, or may even be forced back toward their place of origin.

Every depression which is completely surrounded by winds, *abnormal by excess,* will be filled up *in place* within twenty-four hours, often even in twelve hours; this is the phenomenon which we designate under the name of COMPRESSION OF THE CYCLONE.

On the contrary, every depression, which gives rise to a marked fall in pressure, without causing winds of corresponding force, will deepen, and in consequence apparently feeble depressions are often transformed into true storms.

But the problem is not only to predict whether a depression will fill up or deepen; nor is it sufficient to indicate the extent to within a few millimeters of the variations of pressure in cyclones; it is also necessary, in order to make a more or less perfect forecast of the weather, to establish *the velocity and the path of the center of the depression*—things which no method of forecasting has, up to the present time, enabled us to determine.

The principle which guides us in this estimate—and which is only a consequence of the first—is thus exprest: *The depression moves toward the region of least resistance.*

These favorable areas will evidently be made up of zones where the winds are *proportionally* too light for the gradient, and, above all, of regions where the winds are *divergent* with reference to the center of the depression considered.

Hence, every barometric low which is prest on one side by winds *abnormal by excess* will move toward the region of least resistance; whether this region be to the north, to the south, to the east, even to the west of the center; and often *whatever may be the distance from the center to this region.* This is the explanation of the apparently capricious directions followed by certain tempests; and it is, at the same time, the basis for predicting the translation, sometimes to prodigious distances, of the centers of storms.

To summarize, in the principle of the *normal wind* we have a safe and rational basis, not only for predicting barometric variations, but for determining whether a depression will or will not assume importance; whether it will fill up or deepen; whether it will retrograde or advance rapidly along a path more or less regular. We can, in addition, establish with sufficient approximation, the region which ought to be covered by the center of the depression on the following day; hence these three problems of the *extent*, the *direction*, and the *velocity* of the motion of storms are completely solved.

This is not sufficient. It is of importance to establish the regions where the rise and fall of pressure will attain their *maximum* intensity. These maximum variations do not always correspond to the maximum and minimum pressures. It is in the region of *least resistance*—or where the winds are simply light—that we locate these oscillations (maximum rise or fall). But we wish to be still more precise and even indicate the stations which will record, on the following day, the maximum rise and fall within the twenty-four hours.

This problem, the most interesting of all perhaps, is solved by the aid of this hypothesis: *The air flows in a direction perpendicular and to the right of the wind which is proportionally too strong.* Therefore the maximum rise or fall takes place *in a straight line* in this direction [i. e., perpendicular to the excessive wind]. Consequently, if the *converging* winds bring the air, or at least the pressure, straight toward the center, *along the gradient*, normal to the isobars, and tend to fill up the center—just as if the cyclonic system were stationary and independent of the rotation of the earth—then the *diverging* winds operate in an opposite direction. Instead of concentrating the pressure they produce a dispersion, that is to say, a void, and this void *is a re-pression.* We approach here very closely the cause of the origin of cyclones. Moreover, the application of our principles and of our hypothesis to the examination of anticyclones enables us to forecast their formation and *their dissipation.*

As the movement of cyclones and of anticyclones determines in general the force and the direction of winds and nearly all the phenomena of heat or cold, of rain or fine weather, of cloudiness or humidity, the principle of the *normal wind*, with its natural consequences, *creates*, in the literal sense of the word, a new method of forecasting the weather.

It is immediately applicable to the synoptic charts, such as those of the Central Meteorological Bureau of France, without introducing any modification.

Certain progress will be the consequence of this application, as our principles are applicable at all times of the year, and the rare errors that occur in practise are due, not to the principles, but to the inexperience of the interpreter, or to the difficulties which result from the simultaneous occurrence of several depressions, or to the sudden arrival of storms from the ocean.

Clouds, or the *succession of clouds*, as we demonstrated in 1886, announce the approach of these oceanic depressions. Once upon the continent, they can be followed by our method. The art of weather forecasting, empirical up to the present time, without strict rules, and based upon an incommunicable personal experience, will then become scientifically established.

OBSERVATIONS OF HALOS AT COLUMBIA, MO.

By GEORGE REEDER, Section Director. Dated Columbia, Mo., May 21, 1907.

My observations of halos at Columbia, Mo., have been carefully made and recorded, and I have found that halos are a very good guide in predicting weather changes, especially the 22-degree circles. I have noted that when the 22-degree circle is observed precipitation usually occurs within twelve to eighteen hours, the storm center crossing the meridian near the point of observation. In such cases the upper clouds undergo rapid changes, becoming thick and matted as they change from cirro-stratus to alto-stratus. When the 45-degree circle is observed the storm center is usually from 800 to 1000 miles or more away and precedes precipitation, if any, by twenty-four to thirty-six hours. I have known the 45-degree circle to continue for three hours or more, with colors well defined, the cirro-stratus clouds being apparently of the most delicate texture and changing their form slowly. If the center of disturbance is directly west of the point of observation, or nearly so, the 45-degree circle may be taken as a very sure sign that precipitation will occur within the succeeding thirty-six hours at this station; but it frequently happens that the storm center crosses the meridian far to the south, and then precipitation does not occur at the point of observation. Well-defined 45-degree circles have been observed around the sun at this station when a West Indian hurricane was immediately off or near the east Gulf or South Atlantic States, but of course in such cases no precipitation occurred at the point of observation. A very brilliant solar halo on September 27, 1906, was the first indication that a Gulf storm was moving northward, entering the mainland near the mouth of the Mississippi River. The storm moved up the valley quite rapidly, and rain was falling over the greater part of Missouri just twelve hours after the halo was observed.

The following are the dates upon which halos were observed during the years 1905 and 1906. February, 1905, was abnormally cold and solar halos were unusually numerous:

January 5, 1905, 10 a. m., solar halo, 22°, bright for one hour. Snow on the 6th.

January 8, 1905, 9 a. m., solar halo, 22°, bright and well defined until 9:30 a. m., disappeared at 10 a. m. Snow began falling at 7:45 p. m. same day, continuing into the night.

January 14, 1905, 2:35 p. m., solar halo, 22°, not well defined, very faint in its lower half. Cold and clear on the 15th.

January 28, 1905, 12 noon, solar halo, 22°, well defined; continued until 2:30 p. m. Snow on the 29th.

February 1, 1905, 4 p. m., solar halo, 45°, brilliant. Cloudy and cold on the 2d; snow on the 3d.

February 7, 1905, 1 p. m., solar halo, 22°, well defined, lasting one hour. Snow began falling soon after 12 midnight and continued during the 8th.

February 10, 1905, 10 a. m., solar halo, 22°, exceptionally well defined, continuing until 12 noon; clouds changing from